PART II SCHWESER'S QuickSheet

CRITICAL CONCEPTS FOR THE 2015 FRM® EXAM

MARKET RISK MEASUREMENT AND MANAGEMENT

Value at Risk (VaR)

VaR for a given confidence level occurs at the cutoff point that separates the tail losses from the remaining distribution.

Historical simulation approach: order return observations and find the observation that corresponds to the VaR loss level.

Parametric estimation approach: assumes a distribution for the underlying observations.

- Normal distribution assumption:

$$\text{VaR} = (-\mu_r + \sigma_r \times z_\alpha)$$

- Lognormal distribution assumption:

$$\text{VaR} = (1 - e^{\mu_r - \sigma_r \times z_\alpha})$$

Expected Shortfall

Provides an estimate of tail loss by averaging the VaRs for increasing confidence levels in the tail.

Weighted Historical Simulation Approaches

- *Age-weighted:* adjusts the most recent (distant) observations to be more (less) heavily weighted.
- *Volatility-weighted:* replaces historic returns with volatility-adjusted returns; actual procedure of estimating VaR is unchanged.
- *Correlation-weighted:* updates the variance-covariance matrix between assets in the portfolio.
- *Filtered historical simulation:* relies on bootstrapping of standardized returns based on volatility forecasts; able to capture conditional volatility, volatility clustering, and/or data asymmetry.

Peaks-Over-Threshold (POT)

Application of extreme value theory (EVT) to the distribution of excess losses over a high threshold. One of the goals of using the POT approach is to compute VaR. From estimates of VaR, we can derive the expected shortfall (ES).

Backtesting VaR

- Compares the number of instances when losses exceed the VaR level (exceptions) with the number predicted by the model at the chosen level of confidence.
- *Failure rate:* number of exceptions/number of observations.
- The Basel Committee requires backtesting at the 99% confidence level over one year; establishes zones for the number of exceptions with corresponding penalties (increases in the capital multiplier).

Mapping

Mapping involves finding common risk factors among positions in a given portfolio. It may be difficult and time consuming to manage the risk of each individual position. One can evaluate the value of portfolio positions by mapping them onto common risk factors.

Pearson Correlation Coefficient

Commonly used to measure the linear relationship between two variables:

$$\rho_{XY} = \frac{\text{cov}_{XY}}{\sigma_X \sigma_Y}$$

Spearman's Rank Correlation

Step 1: Order the set pairs of variables *X* and *Y* with respect to set *X*.

Step 2: Determine the ranks of X_i and Y_i for each time period *i*.

Step 3: Calculate the difference of the variable rankings and square the difference.

$$\rho_S = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2 - 1)}$$

Where *n* is the number of observations for each variable and d_i is the difference between the ranking for period *i*.

Kendall's τ

$$\tau = \frac{n_c - n_d}{n(n-1)/2}$$

Where the number of concordant pairs is represented as n_c (pair rankings in agreement), and the number of discordant pairs is represented as n_d (pair rankings not in agreement).

Mean Reversion

- Implies that over time variables or returns regress back to the mean or average return.
- Mean reversion rate, a, is expressed as: $S_t - S_{t-1} = a(\mu - S_{t-1})$
- The β coefficient of a regression is equal to the negative of the mean reversion rate.

Autocorrelation

- Measures the degree that a variable's current value is correlated to past values.
- Has the exact opposite properties of mean reversion.
- The sum of the mean reversion rate and the one-period autocorrelation rate will always equal one.

Correlation Swap

- Used to trade a fixed correlation between two or more assets with a realized correlation.
- Realized correlation for a portfolio of *n* assets:

$$\rho_{\text{realized}} = \frac{2}{n^2 - n}\sum_{i>j}\rho_{i,j}$$

- Payoff for correlation swap buyer: notional amount × $(\rho_{\text{realized}} - \rho_{\text{fixed}})$

Gaussian Copula

- Indirectly defines a correlation relationship between two variables.
- Maps the marginal distribution of each variable to a standard normal distribution (done on percentile-to-percentile basis).
- The new joint distribution is a multivariate standard normal distribution.
- A Gaussian default time copula can be used for measuring the joint probability of default between two assets.

Regression-Based Hedge

$$F^R = F^N \times \left(\frac{DV01^N}{DV01^R}\right) \times \beta$$

where:

F^R = face amount of hedging instrument

F^N = face amount of initial position

Bond Valuation Using Binomial Tree

Using backward induction, the value of a bond at a given node in a binomial tree is the average of the present values of the two possible values from the next period. The appropriate discount rate is the forward rate associated with the node under analysis.

There are three basic steps to valuing an option on a fixed-income instrument using a binomial tree:

Step 1: Price the bond value at each node using the projected interest rates.

Step 2: Calculate the intrinsic value of the derivative at each node at maturity.

Step 3: Calculate the expected discounted value of the derivative at each node using the risk-neutral probabilities and work backward through the tree.

Interest Rate Expectations

Expectations play an important role in determining the shape of the yield curve and can be illustrated by examining yield curves that are flat, upward-sloping, and downward-sloping. If expected 1-year spot rates for the next three years are r_1, r_2, and r_3, then the 2-year and 3-year spot rates are computed as:

$$\hat{r}(2) = \sqrt{(1+r_1)(1+r_2)} - 1$$

$$\hat{r}(3) = \sqrt[3]{(1+r_1)(1+r_2)(1+r_3)} - 1$$

Convexity Effect

All else held equal, the value of convexity increases with maturity and volatility.

Term Structure Models

Model 1: assumes no drift and that interest rates are normally distributed:

$dr = \sigma dw$

Model 2: adds a positive drift term to Model 1 that can be interpreted as a positive risk premium associated with longer time horizons:

$dr = \lambda dt + \sigma dw$

where:

λ = interest rate drift

Ho-Lee Model: generalizes drift to incorporate time-dependency:

$dr = \lambda(t)dt + \sigma dw$

Vasicek Model: assumes a mean-reverting process for short-term interest rates:

$dr = k(\theta - r)dt + \sigma dw$

where:

k = a parameter that measures the speed of reversion adjustment

θ = long-run value of the short-term rate assuming risk neutrality

r = current interest rate level

Model 3: assigns a specific parameterization of time-dependent volatility:

$dr = \lambda(t)dt + \sigma e^{-\alpha t}dw$

where:

σ = volatility at t = 0, which decreases exponentially to 0 for $\alpha > 0$

Cox-Ingersoll-Ross (CIR) model: mean-reverting model with constant volatility, σ, and basis-point volatility, $\sigma\sqrt{r}$, that increases at a decreasing rate:

$dr = k(\theta - r)dt + \sigma\sqrt{r}dw$

Model 4 (lognormal model): yield volatility, σ, is constant, but basis-point volatility, σr, increases with the level of the short-term rate. There are two lognormal models of importance: (1) lognormal with deterministic drift and (2) lognormal with mean reversion.

Overnight Indexed Swaps (OIS)

Interest rate swap in which a fixed interest rate is swapped for a floating interest rate. The OIS rate is the best proxy for the risk-free rate in the valuation of collateralized derivatives portfolios.

Put-Call Parity

$c - p = S - Xe^{-rT}$

where:

c = price of a call

p = price of a put

S = price of the underlying security

r = risk-free rate

T = time left to expiration expressed in years

Volatility Smiles

Currency options: implied volatility is lower for at-the-money options than it is for away-from-the-money options. If the implied volatilities for actual currency options are greater for away-from-the-money than at-the-money options, currency traders must think there is a greater chance of extreme price movements than predicted by a lognormal distribution.

Equity options: higher implied volatility for low strike price options. The volatility smirk (half-smile) exhibited by equity options translates into a left-skewed implied distribution of equity price changes. This indicates that traders believe the probability of large down movements in price is greater than large up movements in price, as compared with a lognormal distribution.

CREDIT RISK MEASUREMENT AND MANAGEMENT

Credit Risk

- *Credit risk* is either the risk of economic loss from default, or changes in credit events or credit ratings.
- Types of credit risky securities include: corporate and sovereign debt, credit derivatives, and structured credit products. Their interest rates include a credit spread above credit risk-free securities.

Expected Loss (EL)

Expected value of a credit loss:

EL = PD × (1 – RR) × exposure = PD × LGD

Probability of default (PD): likelihood that a borrower will default within a specified time horizon.

Loss given default (LGD): amount of creditor loss in the event of a default. In percent terms, it is equal to 1 minus the recovery rate (i.e., 1 – RR).

Exposure at default: amount of money the lender can lose in the event of a borrower's default.

The Merton Model

- A value-based model where the value of the firm's outstanding debt (*D*) plus equity (*E*) is equal to the value of the firm (*V*).
- The value of the debt can serve as an indicator of firm default risk.
- Since *E* and *D* are contingent claims, option pricing can be used to determine their values as follows:

  payment to shareholders: $\max(V_M - D_M, 0)$

  payment to debtholders: $D_M - \max(D_M - V_M, 0)$
- Equity is similar to a long call option on the value of a firm's assets where face value of debt is the strike price of the option.
- Debt is similar to a risk-free bond and short put option on the value of a firm's assets where face value of debt is the strike price of the option.

The KMV Model

Built on the Merton model and tries to adjust for some of its shortcomings. Assumes there are only two debt issues. The default threshold is a linear combination of these values and is equal to the par value of the firm's liabilities. A rule for determining the default threshold is:

short-term liabilities + 0.5 × long-term liabilities

The distance to default (DD) calculates the number of standard deviations between the mean of the asset distribution and the default threshold.

$$DD = \frac{\text{expected asset value} - \text{default threshold}}{\text{standard deviation of expected asset value}}$$

Once DD is computed, the probability of default can be found by evaluating the DD of other firms that have defaulted.

Credit Scoring Models

- *Fisher linear discriminant analysis:* segregates a larger group into homogeneous subgroups.
- *Parametric discrimination:* uses a score function to determine the members of the subgroups. The score determines which subgroup the observation is placed in (likely-to-default or not-likely-to-default group).
- *K-nearest neighbor:* categorizes a new entrant by how closely it resembles members already in groups.
- *Support vector machines:* divides larger group into subgroups using hyperplanes.

Credit Spread

Difference between the yield on a risky bond (e.g., corporate bond) and the yield on a risk-free bond (e.g., T-bond) given that the two instruments have the same maturity.

$$CS = -\left[\frac{1}{(T-t)}\right] \times \ln\left(\frac{D}{F}\right) - R_F$$

where:

D = current value of debt

F = face value of debt

Credit Risk Portfolio Models

These models attempt to estimate a portfolio's credit value at risk. Credit VaR differs from market VaR in that it measures losses that are due specifically to default risk and credit deterioration risk.

CreditRisk+: determines default probability correlations and default probabilities by using a set of common risk factors for each obligor.

CreditMetrics: uses historical data to estimate the probability of a bond being upgraded or downgraded using historical transition matrices.

KMV Portfolio Manager: default probability is a function of firm asset growth and the level of debt. The higher the growth and lower the debt level, the lower the default probability.

CreditPortfolioView: multifactor model for simulating joint conditional distributions of credit migration and default probabilities that incorporates macroeconomic factors.

Credit Derivatives

A credit derivative is a contract with payoffs contingent on a specified credit event. Credit events include:

- Failure to make required payments.
- Restructuring that harms the creditor.
- Invocation of cross-default clause.
- Bankruptcy.

Credit default swap (CDS): like insurance; party selling the protection receives a fee, pays based on swap's notional amount in the case of default.

Basket CDS: CDS on a portfolio of assets where the payoff occurs based on a predetermined credit event. Most common is a first-to-default swap, which makes a payoff when the first reference entity in the basket defaults. Other basket CDSs are referred to as *n*th-to-default CDSs, where the payoff occurs when the *n*th default occurs in a portfolio of companies.

Total return swap: total return on an asset (bond) is exchanged for a fixed (or variable) payment; total return receiver gets any appreciation (capital gains and cash flows), pays any depreciation; payments take place whether or not a credit event occurs. Buyer exchanges credit risk of issuer defaulting for the combined risk of the issuer and the derivative counterparty.

Vulnerable option: option with default risk; holder receives promised payment only if seller of the option is able to make the payment.

Credit-linked note: holder receives an enhanced coupon to compensate for bearing the credit risk of the issuer.

Spread Conventions

Yield spread: YTM risky bond – YTM benchmark government bond

i-spread: YTM risky bond – linearly interpolated YTM on benchmark government bond

z-spread: basis points added to each spot rate on a benchmark curve

CDS spread: market premium of CDS of issuer bond

Hazard Rates

The hazard rate (default intensity) is represented by the (constant) parameter λ and the probability of default over the next, small time interval, *dt*, is λdt.

Cumulative PD

If the time of the default event is denoted t*, the cumulative default time distribution *F(t)* represents the probability of default over (0, t):

$$P(t^* < t) = F(t) = 1 - e^{-\lambda t}$$

The survival distribution is:

$$P(t^* \geq t) = 1 - F(t) = e^{-\lambda t}$$

Probability of Default

The probability of default (PD) of a debt security can be calculated by using the following equation:

$$PD = \frac{CS}{LGD}$$

CS represents the credit spread, which is the difference between the yield on risky debt and the risk-free rate. Loss given default (LGD) is equal to one minus the recovery rate.

Single-Factor Model

Examines the impact of varying default correlations based on a credit position's beta. Each individual firm or credit, *i*, has a beta correlation, β_i, with the market, *m*. Firm *i*'s individual asset return is defined as:

$$a_i = \beta_i m + \sqrt{1-\beta_i^2}\varepsilon_i$$

where:

$\sqrt{1-\beta_i^2}$ = firm's standard deviation of idiosyncratic risk

ε_i = firm's idiosyncratic shock

Tranching

- Divides claims against an asset's cash flows into a specific order.
- Claims with the most seniority have implicit protection from the layer of investors below them, and so on. Structuring the claims in this fashion creates subordination at clearly defined break points or attachment points.
- An example capital structure might consist of an equity tranche, a mezzanine tranche, and a senior tranche.

Collateralized Debt Obligations

- General term for an asset-backed security that issues securities that pay principal and interest from a collateral pool of debt instruments.
- In order to create a CDO, the issuer packages a series of debt instruments and splits the package into several classes of securities called tranches.
- The largest part of a CDO is typically the senior tranche, which usually carries a AA or AAA credit rating, regardless of the quality of the underlying assets in the pool.

Balance sheet CDO: motivated by the asset owner wishing to remove the selected assets from the balance sheet.

Arbitrage CDOs: financially engineered products designed to profit on the spread between the assets in the pool and the promised payments to security holders.

Synthetic CDO: created by selling a portfolio of CDSs to third parties and passing off the credit risk to the synthetic CDO's tranche holders. The structure of a synthetic CDO is the same as that under a cash CDO, without a legal sale of assets.

Securitization

Originator packages assets, carves out the assets' cash flows, and sells the cash flow carve-outs to individual investors.

- Credit support typically comes in the form of a senior/subordinated tranche structure, excess spread, cash reserve account, or overcollateralization.
- Securitization can impact the financial condition of the issuer based on the amount of risk the issuer maintains. The originator may retain risk by holding the riskiest positions or by providing credit support.

Subprime Mortgage Market

- Subprime borrowers have a history of either default or strong indicators of possible future default.
- Indicators of future default: past delinquencies, judgments, foreclosures, repossessions, charge-offs, and bankruptcy filings; low FICO scores; high debt service ratio of 50% or more.
- The vast majority of subprime loans are adjustable rate mortgages.

Counterparty Risk

The risk that a counterparty is unable or unwilling to live up to its contractual obligations.

Credit exposure: loss that is "conditional" on the counterparty defaulting.

Recovery: measured by the recovery rate, which is the portion of the outstanding claim actually recovered after default.

Wrong-way exposures: exposures that are negatively correlated with the counterparty's credit quality. They increase expected credit losses.

Mark-to-market (MtM): accrual accounting measure that is equal to the sum of the MtM values of all contracts with a given counterparty.

Credit Exposure Metrics

Expected MtM: forward or expected value of a transaction at a given point in the future.

Expected exposure (EE): amount that is expected to be lost (positive MtM only) if the counterparty defaults.

Potential future exposure (PFE): worst exposure that could occur at a given time in the future at a given confidence level.

Expected positive exposure (EPE): average EE through time.

Effective EE: equal to non-decreasing EE.

Effective EPE: average of effective EE.

Maximum PFE: highest PFE value over a stated time frame.

Credit Mitigation Techniques

Netting: a legally binding agreement that enables counterparties with multiple derivative contracts to net their obligations (e.g., Party A owes Party B $50 million; Party B owes Party A $40 million, so Party A pays a net $10 million to Party B).

Collateralization: if the value of derivative contracts is above a stated threshold, collateral must equal the difference between the value of the contracts and the threshold level. Collateral agreements have two major benefits: (1) expand the list of potential counterparties because credit rating is a less important concern and (2) reduce economic capital requirements.

Modeling Collateral

Certain parameters impact the effectiveness of collateral in lessening credit exposure. These parameters are as follows:

Remargin period: the time between the call for collateral and its receipt.

Threshold: an exposure level below which collateral is not called. It represents an amount of uncollateralized exposure.

Minimum transfer amount: the minimum quantity or block in which collateral may be transferred. Quantities below this amount represent uncollateralized exposure.

Independent amount: an amount posted independently of any subsequent collateralization. This is also referred to as the initial margin.

Rounding: the process by which a collateral call amount will be adjusted (rounded) to a certain increment.

Credit Value Adjustment (CVA)

Expected value or price of counterparty credit risk. A positive value represents a cost to the counterparty that bears a greater propensity to default. The CVA should account for the counterparty's default probability, the transaction in question, netting, collateral, and hedging.

$$CVA \approx LGD \times \sum_{i=1}^{m} d(t_i) \times EE(t_i) \times PD(t_{i-1}, t_i)$$

where:

d(t) = discount factors

Incremental and Marginal CVA

- *Incremental CVA* calculates the cost of a new trade versus an existing one to determine the effect that the new trade has on CVA. The formula is identical to stand-alone CVA, except for the use of incremental expected exposure.
- *Marginal CVA* is used for trade level attribution. The formula is identical to stand-alone CVA, except for the use of marginal expected exposure.

Risk-Neutral Default Probability

Represents estimates of default probability based on observed market prices of securities (e.g., bonds, credit default swaps).

risk-neutral default probability = real-world default probability + liquidity premium + default risk premium

Wrong-Way Risk vs. Right-Way Risk

Wrong-way risk: increases counterparty risk [increases credit value adjustment (CVA) and decreases debt value adjustment (DVA)].

Right-way risk: decreases counterparty risk (decreases CVA and increases DVA).

OPERATIONAL AND INTEGRATED RISK MANAGEMENT

Risk-Adjusted Return on Capital

The RAROC measure is essential to successful integrated risk management. Its main function is to relate the return on capital to the riskiness of firm investments. The RAROC is the risk-

adjusted return divided by risk-adjusted capital (e.g., economic capital).

$$\text{RAROC} = \frac{\text{revenues} - \text{EL} - \text{expenses} + \text{return on economic capital} \pm \text{transfer price}}{\text{economic capital}}$$

An adjusted RAROC (ARAROC) measure was developed to better align the risk of the business with the risk of the firm's equity.

$$\text{ARAROC} = \frac{(\text{RAROC} - R_F)}{\beta_E}$$

Liquidity Risk

The lack of a market for a security to prevent it from being bought or sold quickly enough to prevent or minimize a loss. It could result from asset allocation, funding strategies, collateral policies, or mismanagement of risks.

Transactions liquidity risk: risk that the act of buying or selling an asset will result in an adverse price move.

Funding liquidity risk: results when a borrower's credit position is either deteriorating or is perceived by market participants to be deteriorating.

Liquidity-Adjusted VaR

The *constant spread approach* calculates liquidity-adjusted VaR (LVaR) assuming the bid-ask spread is constant.

$$\text{LVaR} = (V \times z_\alpha \times \sigma) + (0.5 \times V \times \text{spread})$$
$$\text{LVaR} = \text{VaR} + \text{liquidity cost}$$

where:
V = asset value
z_α = VaR confidence parameter
σ = standard deviation of returns

$$\text{spread} = \frac{(\text{ask price} - \text{bid price})}{(\text{ask price} + \text{bid price})/2}$$

LVaR can also be calculated given the distributional characteristics of the spread. This is known as the *exogenous spread approach*. If you are given the mean and standard deviation of the spread, apply the following formula:

$$\text{LVaR} = \text{VaR} + 0.5 \times (\mu_S + z'_\alpha \times \sigma_S) \times V$$

where:
μ_S = spread mean
σ_S = spread standard deviation
z'_α = spread confidence parameter

Liquidity at Risk (LaR)

- Maximum likely cash outflow over the horizon period at a specified confidence level.
- Also known as cash flow at risk (CFaR).
- A positive (negative) value for LaR means the worst outcome will be associated with an outflow (inflow) of cash.
- LaR is similar to VaR, but instead of a change in value, it deals with cash flows.

Model Risk

The risk associated with using financial models to simulate complex relationships. Sources of model risk include incorrect model application, implementation risk, calibration errors, programming errors, and data problems.

Enterprise Risk Management (ERM)

In developing an ERM system, management should follow the following framework:

- Determine the firm's acceptable level of risk.
- Based on the firm's target debt rating, estimate the capital (i.e., buffer) required to support the current level of risk in the firm's operations.
- Determine the ideal mix of capital and risk that will achieve the appropriate debt rating.
- Give individual managers the information and the incentive they need to make decisions appropriate to maintain the risk/capital trade-off.

The implementation steps of ERM are as follows:

- Identify the risks of the firm.
- Develop a consistent method to evaluate the firm's exposure to the identified risks.

Firm-Wide VaR

- Firms that use value at risk (VaR) to assess potential loss amounts will have multiple VaR measures to manage.
- Market risk, credit risk, and operational risk will each produce its own VaR measures.
- Due to diversification effects, firm-wide VaR will be less than the sum of the VaRs from each risk category.

Leverage Ratio

A firm's leverage ratio is equal to its assets divided by equity:

$$L = \frac{A}{E} = \frac{(E + D)}{E} = 1 + \frac{D}{E}$$

Leverage Effect

Return on equity (ROE) is higher as leverage increases, as long as the firm's return on assets (ROA) exceeds the cost of borrowing funds. The leverage effect can be expressed as:

ROE = (leverage ratio × ROA) – [(leverage ratio – 1) × cost of debt]

Transaction Cost

The 99% confidence interval on transaction cost is:

$+/- P \times ½(s + 2.33\sigma_s)$

where:
P = estimate of the next day asset midprice
s = bid-ask spread
$½(s + 2.33\sigma_s)$ = 99% spread risk factor

Operational Risk Data Elements

The four data elements that a bank must use in various combinations to calculate the operational risk capital charge based on the AMA framework are (1) internal loss data, (2) external loss data, (3) scenario analysis, and (4) business environment and internal control factors (BEICFs).

Basel II Operational Risk Event Types

- Internal Fraud.
- External Fraud.
- Employment Practices and Workplace Safety.
- Clients, Products, and Business Practices.
- Damage to Physical Assets.
- Business Disruption and System Failures.
- Execution, Delivery, and Process Management.

External Loss Data

IBM Algo FIRST: subscription database; includes descriptions and analyses of operational risk events derived from legal and regulatory sources and news articles.

Operational Riskdata eXchange Association (ORX): consortium-based risk event service; gathers anonymous operational risk events from members.

Loss Distribution Approach

The loss distribution approach (LDA) is used to meet the Basel II operational risk standards for regulatory capital. The LDA has several steps:

- Organize and group loss data into a business line/event type matrix.
- Weight every data point in the matrix.
- Model a loss distribution in each cell of the matrix.
- Determine the operational risk capital requirements for each business line.

Frequency Distributions

- LDA models most often use the Poisson distribution, the negative binomial distribution, or the binomial distribution.
- Practitioners suggest only using internal data because it is most relevant and it is difficult to ensure the completeness of external data.
- Modeling the frequency distribution requires less data when compared to modeling severity.

Severity Distributions

- The severity of each event follows a parametric distribution, such as a lognormal distribution or a Weibull distribution.
- Severity distributions are generally considered more important than frequency distributions.
- One problem with modeling severity is that recent internal loss data may not be sufficient for calibrating the tails of the distribution.
- Using external data usually requires scaling the data and combining data from several sources.

Repurchase Agreements (Repos)

- Bilateral contracts where one party sells a security at a specified price with a commitment to buy back the security at a future date at a higher price.
- From the perspective of the *borrower*: repos offer relatively cheap sources of short-term funds.
- From the perspective of the *lender*: reverse repos are used for either investing or financing purposes.

Capital Plan Rule

- Mandates that bank holding companies develop a capital plan and evaluate capital adequacy.
- Capital adequacy process includes: risk management foundation, resource and loss estimation methods, impact on capital adequacy, capital planning and internal controls policies, and governance oversight.

Operational Risk Governance

The Basel Committee recognizes three common lines of defense used to control operational risks: (1) business line management, (2) independent operational risk management function, and (3) independent reviews of operational risks and risk management.

Risk Appetite Framework (RAF)

- Sets in place a clear, future-oriented perspective of the firm's target risk profile in a number of different scenarios and maps out a strategy for achieving that risk profile.
- Should start with a risk appetite statement that is essentially a mission statement from a risk perspective.
- Benefits include assisting firms in preparing for the unexpected and greatly improving a firm's strategic planning and tactical decision-making.

Basel II: Three Pillars

Pillar 1: Minimum capital requirements. Banks should maintain a minimum level of capital to cover credit, market, and operational risks.

Pillar 2: Supervisory review process. Banks should assess the adequacy of capital relative to risk, and

supervisors should review and take corrective action if problems occur.
Pillar 3: Market discipline. Risks should be adequately disclosed in order to allow market participants to assess a bank's risk profile and the adequacy of its capital.

Basel II: Forms of Capital

Tier 1: shareholder's equity, retained earnings; nonredeemable, noncumulative preferred stock.
Tier 2: undisclosed reserves, revaluation reserves, general provisions/general loan-loss reserves, hybrid debt capital instruments, and subordinated term debt.

Credit Risk Capital Requirements

The *standardized approach* incorporates risk weights based on external credit rating assessments. The amount of capital that a bank must hold is specific to the risk of credit-risky assets, the type of institution the claim is written on, and the maturity of those assets.
The *internal ratings-based (IRB) approaches* (foundation and advanced) use a bank's own internal estimates of creditworthiness to determine the risk weightings in the capital calculation.

- *Foundation approach:* bank estimates probability of default (PD).
- *Advanced approach:* bank estimates not only PD, but also loss given default (LGD), exposure at default (EAD), and effective maturity (M).

Market Risk Capital Requirements

Standardized method: determines capital charges associated with various market risk exposures (equity risk, interest rate risk, foreign exchange risk, commodity risk, and option risk). The market risk capital charge for each market risk is computed as 8% of its market-risky assets.
Internal models approach (IMA): allows a bank to use its own risk management systems to determine its market risk capital charge. The market risk charge is the higher of (1) the previous day's VaR or (2) the average VaR over the last 60 business days adjusted by a multiplicative factor (subject to a floor of 3).

Backtesting VaR

An exception occurs if the day's change in value exceeded the VaR estimate of the previous day. When backtesting VaR, the number of exceptions is determined for a 250-day testing period. Based on the number of exceptions, the bank's exposure is categorized into one of three zones and VaR is scaled up by the appropriate multiplier (subject to a floor of 3).

- Green zone: 0–4 exceptions, increase in exposure multiplier is 0.
- Yellow zone: 5–9 exceptions, exposure multiplier increases between 0.4 and 0.85.
- Red zone: Greater than or equal to 10 exceptions, multiplier increases by 1.

Operational Risk Capital Requirements

Basic indicator approach: measures the capital charge on a firm-wide basis. Banks will hold capital for operational risk equal to a fixed percentage of the bank's average annual gross income over the prior three years. The Basel Committee has proposed a fixed percentage equal to 15%.
Standardized approach: allows banks to divide activities along standardized business lines. Within each business line, gross income will be multiplied by a fixed beta factor. The capital charge for operational risk is the sum of each business line's charges. The beta factors for the eight business lines are as follows:

- Trading and sales: 18%
- Corporate finance: 18%
- Payment, settlement: 18%
- Commercial banking: 15%
- Agency services: 15%
- Retail banking: 12%
- Retail brokerage: 12%
- Asset management: 12%

Advanced Measurement Approach (AMA): If a bank can meet more rigorous supervisory standards, it may use the AMA for operational risk capital calculations. The capital charge for AMA is calculated as the bank's operational value at risk (OpVaR) with a 1-year horizon and a 99.9% confidence level. Having insurance can reduce this capital charge by as much as 20%.

Basel III Changes

- Raise capital standards (both quality and quantity).
- Strengthen risk coverage of capital framework.
- Require leverage ratio to supplement capital requirements.
- Promote countercyclical buffers during financial shocks.
- Institute policies to address systemic risk and interconnectedness.
- Institute global liquidity standard (liquidity, funding, and monitoring metrics).

Liquidity Coverage Ratio

Goal: ensure banks have adequate, high-quality liquid assets to survive short-term stress scenario.

LCR = (stock of high-quality liquid assets / total net cash outflows over next 30 calendar days) > 100

Net Stable Funding Ratio

Goal: protect banks over a longer time horizon than LCR.

NSFR = (available amount of stable funding / required amount of stable funding) > 100

Stressed Value at Risk

SVaR is calculated by combining current portfolio performance data with the firm's historical data from a significantly financial stressed period in the same portfolio. Calculation of SVaR is defined as follows:

$$\max(\text{SVaR}_{t-1},\ \text{multiplicative factor} \times \text{SVaR}_{\text{avg}})$$

Solvency II

Establishes capital requirements for the operational, investment, and underwriting risks of insurance companies.

- Specifies minimum capital requirements (MCR) and solvency capital requirements (SCR).
- SCR may be calculated using either standardized approach or internal models approach.
- *Standardized approach:* Intended for less sophisticated insurance firms; captures the risk profile of the average insurance firm.
- *Internal models approach:* Similar to the IRB approach under Basel II. A VaR is calculated with a one-year time horizon and a 99.5% confidence level.

Dodd-Frank

Intended to protect consumers from abuses and prevent future bailouts and/or collapses of banks and other financial firms.

- Established Financial Stability Oversight Council (FSOC).
- Established Office of Financial Research (OFR).
- Established Volcker Rule, intended to curtail proprietary trading by banks.
- Banks considered too-big-to-fail must be identified and could be broken up if their living wills are judged unacceptable.
- Increased regulation and improved transparency for over-the-counter (OTC) derivatives.

RISK MANAGEMENT AND INVESTMENT MANAGEMENT

Portfolio Construction Techniques

- *Screens* simply choose assets by ranking alpha.
- *Stratification* chooses stocks based on screens; includes assets from all asset classes.
- *Linear programming* attempts to construct a portfolio that closely resembles the benchmark.
- *Quadratic programming* explicitly considers alpha, risk, and transactions costs.

Portfolio Risk

Diversified VaR:

$$\text{VaR}_P = Z_c \times P \times \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2\sigma_1\sigma_2\rho_{1,2}}$$

Undiversified VaR:

$$\text{VaR}_P = \sqrt{\text{VaR}_1^2 + \text{VaR}_2^2 + 2\text{VaR}_1\text{VaR}_2} = \text{VaR}_1 + \text{VaR}_2$$

VaR for Uncorrelated Positions:

$$\text{VaR}_P = \sqrt{\text{VaR}_1^2 + \text{VaR}_2^2}$$

Marginal VaR: per dollar change in portfolio VaR that occurs from an additional investment in a position.

$$\text{MVaR}_i = \frac{\text{VaR}_P}{\text{portfolio value}} \times \beta_i$$

How to use MVaR:

- Obtain the optimal portfolio: equate the excess return/MVaR ratios of all portfolio positions.
- Obtain the lowest portfolio VaR: equate just the MVaRs of all portfolio positions.

Incremental VaR: change in VaR from the addition of a new position in a portfolio.
Component VaR: amount of risk a particular fund contributes to a portfolio of funds.

$$\text{CVaR}_i = \text{MVaR}_i \times w_i \times P = \text{VaR} \times \beta_i \times w_i$$

Risk Budgeting

Manager establishes a risk budget for the entire portfolio and then allocates risk to individual positions based on a predetermined fund risk level. The risk budgeting process differs from market value allocation since it involves the allocation of risk.
Budgeting risk across asset classes: selecting assets whose combined VaRs are less than the total allowed.
Budgeting risk across active managers: the optimal allocation is achieved with the following formula:

$$\text{weight of portfolio managed by manager } i = \frac{\text{IR}_i \times \text{portfolio's tracking error}}{\text{IR}_P \times \text{manager's tracking error}}$$

Liquidity Duration

Approximation of the number of days necessary to dispose of a portfolio's holdings without a significant market impact.

$$LD = \frac{\text{number of shares of a security}}{[\text{desired max daily volume (\%)} \times \text{daily volume}]}$$

Time-Weighted and Dollar-Weighted Returns

Dollar-weighted rate of return: the internal rate of return (IRR) on a portfolio taking into account all cash inflows and outflows.

Time-weighted rate of return: measures compound growth. It is the rate at which $1 compounds over a specified time horizon.

Measures of Performance

The *Sharpe ratio* calculates the amount of excess return (over the risk-free rate) earned per unit of total risk. It uses standard deviation as the relevant measure of risk.

$$S_A = \frac{\overline{R}_A - \overline{R}_F}{\sigma_A}$$

where:

$\overline{R}_A$ = average account return
$\overline{R}_F$ = average risk-free return
σ_A = standard deviation of account returns

The *Treynor measure* is very similar to the Sharpe ratio except that it uses beta (systematic risk) as the measure of risk. It shows excess return (over the risk-free rate) earned per unit of systematic risk.

$$T_A = \frac{\overline{R}_A - \overline{R}_F}{\beta_A}$$

where:

$\overline{R}_A$ = average account return
$\overline{R}_F$ = average risk-free return
β_A = average beta

Jensen's alpha is the difference between actual return and return required to compensate for systematic risk. To calculate the measure, subtract the return calculated by the capital asset pricing model (CAPM) from the account return.

$$\alpha_A = R_A - E(R_A)$$

where:

α_A = alpha
R_A = the return on the account
$E(R_A) = R_F + \beta_A[E(R_M) - R_F]$

The *information ratio* is the ratio of surplus return (in a particular period) to its standard deviation. It indicates the amount of risk undertaken (denominator) to achieve a certain level of return above the benchmark (numerator).

$$IR_A = \frac{\overline{R}_A - \overline{R}_B}{\sigma_{A-B}}$$

where:

$\overline{R}_A$ = average account return
$\overline{R}_F$ = average risk-free return
σ_{A-B} = standard deviation of excess returns measured as the difference between account and benchmark returns

The *M-squared (M^2) measure* compares return earned on the managed portfolio against the market return, after adjusting for differences in standard deviations between the two portfolios. It can be illustrated by comparing the CML for the market index and the CAL for the managed portfolio. The difference in return between the two portfolios equals the M^2 measure.

Performance Attribution

Asset allocation attribution equals the difference in returns attributable to active asset allocation decisions of the portfolio manager.

Selection attribution equals the difference in returns attributable to superior individual security selection (correct selection of mispriced securities) and sector allocation (correct over- and underweighting of sectors within asset classes).

Hedge Fund Strategies

Equity long/short strategy: go long and short similar securities to exploit mispricings—decreases market risk and generates alpha.

Global macro strategy: makes leveraged bets on anticipated price movements in broad equity and fixed-income markets, interest rates, foreign exchange, and commodities.

Managed futures strategy: focuses on investments in bond, equity, commodity futures, and currency markets around the world. Employs a high degree of leverage because futures contracts are used.

Fixed-income arbitrage strategy: long/short strategy that looks for pricing inefficiencies between various fixed-income securities.

Convertible arbitrage strategy: investor purchases a convertible bond and sells short the underlying stock.

Merger arbitrage strategy: involves purchasing shares in a target firm and selling short shares in the purchasing firm.

Distressed investing strategy: purchase bonds of distressed company and sell short the stock, anticipating that the shares will eventually be worthless.

Emerging markets strategy: invests in developing countries' securities or sovereign debt.

Fund of hedge funds: perform screening and due diligence of other funds. Fees can be extensive, and the due diligence does not always identify fraud. A key advantage is diversification benefit without large capital commitment.

Illiquid Asset Return Biases

Biases that impact reported illiquid asset returns:

- *Survivorship bias:* Poor performing funds often quit reporting results, ultimately fail, or never begin reporting returns because performance is weak.
- *Selection bias:* Asset values and returns tend to be reported when they are high.
- *Infrequent trading:* Betas, volatilities, and correlations are too low when they are computed using the reported returns of infrequently traded assets.

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CURRENT ISSUES IN FINANCIAL MARKETS

Clearinghouse Advantages

1. Standardizes products and improves price transparency.
2. Centralizes assessment of counterparty risk.
3. Centralizes collection of collateral.
4. Mutualizes risk (spread risks among members).
5. Provides contract netting (risk transfer).

High-Frequency Trading (HFT)

- Computerized quantitative models that identify buy/sell opportunities with the smallest possible delay.
- Look for predictable trading patterns from which to profit.
- Can increase trading speed by locating close to the exchange-matching engine.
- Main benefits are reduced spreads and increased liquidity.

HFT Predatory Algorithms

- *Quote stuffers:* floods an exchange with messages; goal is to slow down competing algorithms.
- *Quote danglers:* orders are entered and instantly canceled; goal is to confuse the quote process.
- *Pack hunters:* HFTs join forces to push a security's price down until stop-loss orders are triggered. They then buy the security after the price has fallen.

Increase Trading Speed

- *Sponsored access:* allows members to send orders directly to exchange-matching engine; however, imposes pre-trade risk controls.
- *Unfiltered sponsored access:* provides firms with direct access to exchanges without pre-trade risk controls; HFTs prefer this access because it reduces latency.

Pre-Trade Risk Controls

- Limit maximum order size.
- Restrict number of sent (orders) messages.
- Price-band mechanisms.
- Stop-logic functionality (halt trading).
- Intraday position and credit limits.

Post-Trade Risk Controls

- *Drop copy:* post trade information is provided to firms by exchanges.
- *Kill button:* allows firm to cancel all existing orders and prevent any new orders.
- *Cancel on disconnect:* allows firm to cancel orders when the firm's server is disconnected from the exchange's server.

Cybersecurity Framework

- Outlines activities that enable an organization to achieve improved cybersecurity outcomes.
- Framework core: (1) identify, (2) protect, (3) detect, (4) respond, and (5) recover.
- Framework profile aligns functions, categories, and subcategories with an organization's business requirements, risk tolerance, and available resources.

Too-Big-To-Fail CCPs

- Central counterparties (CCPs) serve as an intermediary for derivatives transactions.
- With new regulations, CCPs are considered "too-big-to-fail."
- CCPs can mitigate concerns by following proper valuations, calculating default fund and initial margin contributions, and choosing its members.

Funding Value Adjustment (FVA)

Adjustment made by dealer, which allows for recovery of average funding costs for any transactions that are uncollateralized.